Photo Conductor:

Device that its conductivity changes with the light incidence

- Photo diod
  - PN
  - PIN
  - APD
- Photo resistor
- Photo transistor
- Solar cell

General clc's

1- Quantum ~~efficien~~ effieciency η

2)- Rsponsivity $\mathcal{R}$

3)- Response time

4)- Nois Power

$$\eta = \frac{\text{Created carrier flux}}{\text{incident Photon flux}} = \frac{i_{ph}/e}{P_{opt}/h\nu}$$

$$\eta = \frac{i_{ph}}{P_{opt}} \cdot \frac{e}{h\nu}$$

$\mathcal{R}\ (A/w)$

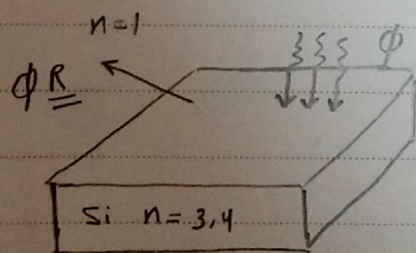
$$\frac{h}{e}\,\frac{c}{\lambda} = \frac{1.24}{\lambda(\mu m)}$$

$$\eta = \mathcal{R} \times \frac{1.24}{\lambda(\mu m)} \implies \mathcal{R} = \frac{\eta \times \lambda(\mu m)}{1.24}$$

$$\eta = (1-R)\,(1-e^{-\alpha d})\,\zeta$$

Energy absorped $= \phi \times (1-R)\,(1-e^{-\alpha d})\,\zeta$

$$1 > \zeta > 0$$



$$\underset{\phi}{I_{in}} \longrightarrow \boxed{(1-e^{-\alpha d})} \longrightarrow I_{in}\,e^{-\alpha d}$$

CR How to maximize η

$\boxed{1}$ - $\underline{R}$ (Reflection) $\ll$ $\Rightarrow$ use Coating (As matched in T.L)

Ex:

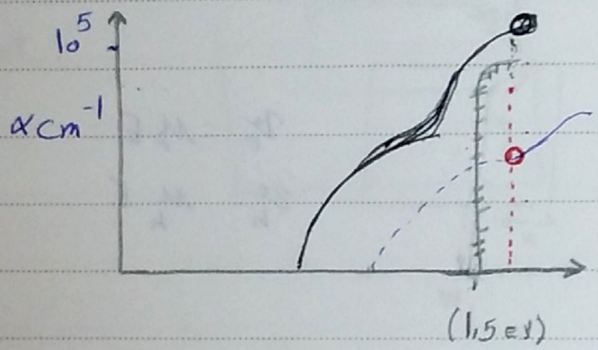
- indium Trin oxide $\underline{\text{Int}}$ (Si)
- Thickness of Coating material (incident wavelength) Designe of $\underline{\text{PD}}$ is tuned at specific wavelengths

$\boxed{2}$ - $e^{-\alpha d} \ll$

$\alpha d \gg$

$\underline{d}$ (thickness) of PD

$\underline{\alpha \uparrow}$



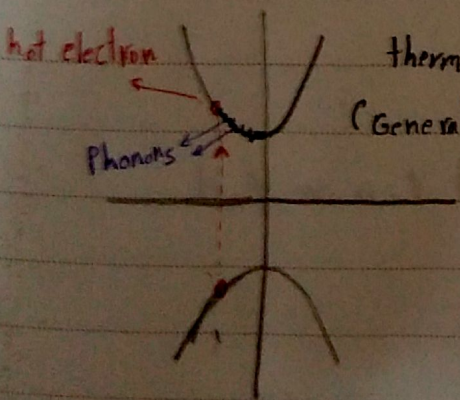
- $1 - e^{-\alpha d} = 0{,}9 \Rightarrow e^{-\alpha d} = 0{,}1$
- $\alpha d = \ln\left(\frac{1}{0{,}1}\right) = \ln(10) = 2{,}303$

$\downarrow$ d = 1mm $\Rightarrow$ $\alpha = \frac{2.303}{10^{-3}} = 2 \times 10^3$

η depend on material $\Longrightarrow$ fabrication

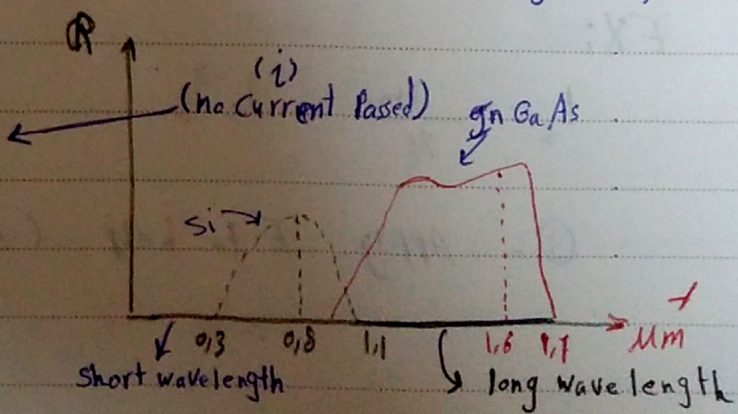
$\Downarrow$

Less defects $\Rightarrow$ less elanglingbonds $\Rightarrow$ less trap state $\Rightarrow$ high Performance



thermilization

(Generate phonon)



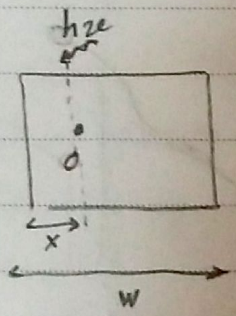
At 1,55 μm In GA As is Commonly used (fiber application)
At 0,3 ⟶ 0,8 Si " " " (Solar cell)

Response time:

How to increas Response tim ?

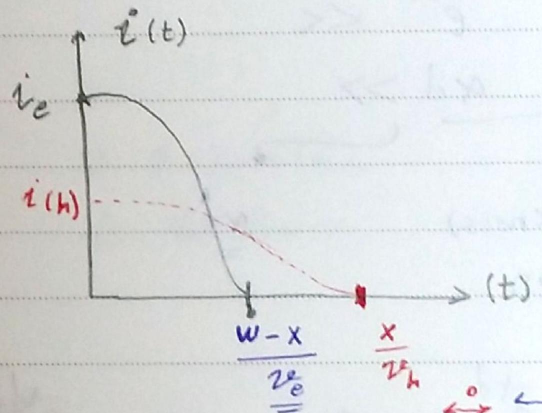
1) Carrier transit time (t)

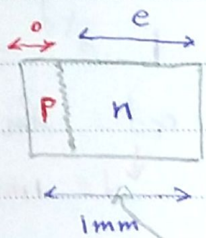
② Carrier recompination time (τ) in circuit (R_L, C)



$v_e = \mu_e E$

$v_h = \mu_h E$





EX :

Si $\mu_e = 1450$, $\mu_h = 450$

In Ga As $\mu_e = 14000$, $\mu_h = 400$

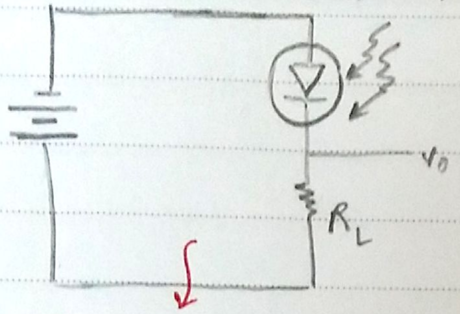
⟹ ①. dimension of n & p layer in PD should be Adjusted as shown above to achieve compromise speed for i_e , i_h

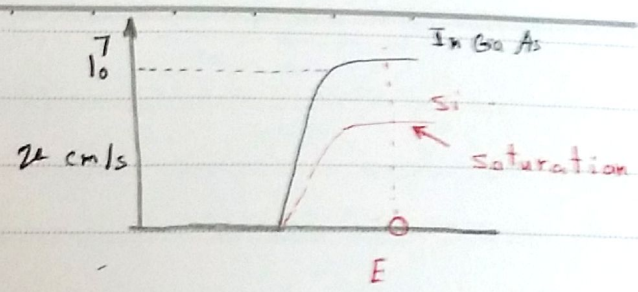
② - Choose material with high mobility

EX:

$t_s = \frac{1mm}{v_e} = 10^{-8} s$ $v_e = 10^7 \; cm/s$

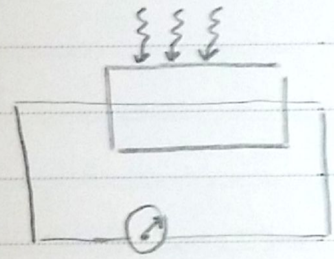
③ - Apply E to help (electrons & holes) to move fast





$\tau = R_L C$

4)- Noise Power:



dark current generated ((reverse current without incident ligh))

for :

Si $\simeq$ 1 nA

In Ga As $\simeq$ 10 nA

Ge $\simeq$ 100 nA

* Common PD Designe is P I N

P-type +Ve

I ↓ intrinsic

N-type -Ve